# ESTIMATES OF BYCATCH OF MACKEREL AND COBIA IN U.S. SOUTH ATLANTIC SHRIMP TRAWLS

Douglas S. Vaughan
National Marine Fisheries Service
Southeast Fisheries Science Center
Beaufort Laboratory
101 Pivers Island Road
Beaufort, North Carolina 28516

and

James M. Nance
National Marine Fisheries Service
Southeast Fisheries Science Center
Galveston Laboratory
4700 Avenue U
Galveston, Texas 77551

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# INTRODUCTION

Estimates of the bycatch of king and Spanish mackerel and cobia were requested to be made for inclusion in the 1996 stock assessments of these species by the Gulf and South Atlantic Fishery Management Councils. Two approaches are used in this report to expand bycatch finfish samples with shrimp trawl catch and effort information to obtain estimates of total finfish bycatch within larger temporal/geographic strata. One, based on expansion by trips, follows that approach outlined in SEAMAP-SA Bycatch Working Group (1995) as submitted to the South Atlantic Fishery Management Council. The other approach, based on finfish:shrimp catches within these strata, was suggested by a reviewer (through the Marine Fisheries Section, AFS) of that report. A final version of the SEAMAP-SA Bycatch Working Group report will be issued during 1996.

## EXPANSION FACTORS BASED ON SHRIMP TRAWL CATCH AND TRIPS

Historical catch, trips, and catch-per-trip are summarized for inside (inlets and internal bays and sounds), outside (0+ miles offshore, ocean), and combined for each U.S. south Atlantic state (FL-NC) in Tables 1-4. Expansion factors based on catch are summarized in Tables 5-7 and based on trips in Tables 8-10. Modification of strata from the SEAMAP-SA Bycatch Working Group (1995) report are summarized by state below. All shrimp trawl catch and effort data for 1995 should be considered preliminary, and probably incomplete for the fall season (i.e., Oct.-Dec. 1995).

Florida: New shrimp catch and effort data were recently provided by Martha Norris (FL DEP, St. Petersburg, FL) from Florida Trip Ticket Program (1986-1995) for the east coast of Florida where each record in the computer file represented one trip (Table 1). Because of large numbers of trips with unknown type (boat or vessel), strata based on this variable were not used as a basis

of stratification in this report.

Although there were also considerable numbers of trips for distance (inside/outside) and latitude (north/south of Jacksonville - 30° N latitude) that were unknown, these stratifying variables were retained. Trips for which these variables (distance and latitude) were known were used to proportion out trips that were unknown. Independently, catches for which these variables (distance and latitude) were known were also used to proportion out catches that were unknown. This way both trips and catches sum to the observed total trips and total catches which include those which are unknown. Outside shrimp trawl trips north of Jacksonville are combined with outside shrimp trawl trips from Georgia and South Carolina to form a single geographic stratum (with four seasonal substrata).

Seasonal definitions for stratification were modified from the SEAMAP Shrimp Bycatch report to allow for fishing year based on April 1 - March 31 (King and Spanish mackerel) and calendar year (cobia). Hence, winter includes Jan-Mar, spring includes Apr-Jun, summer includes Jul-Aug, and fall includes Sep-Dec. Rock shrimp trips were defined as those trips for which rock shrimp were the most abundant in the landings (always outside vessel trips when known and almost entirely south of Jacksonville). Catches associated with rock shrimp trips include all shrimp species landed in those trips.

Stratum expansion factors are summarized for Florida/Inside and Florida/Outside/South for catch (Table 5) and trips (Table 7). Stratum expansion factors are summarized for Florida/ Outside/North for catch (Table 6) and for trips (Table 9).

<u>Georgia:</u> NMFS detailed shrimp trawl data were available from 1978-1995, of which late season 1995 information are preliminary (Table 2). With increasing numbers of trips with unknown distance from shore for recent years, and the historical

precedence that boat trips were almost completely inside and vessel trips were almost completely outside, all boat trips were defined as inside and all vessel trips as outside.

Seasonal definitions for stratification were the same as for Florida. Also, as with Florida, rock shrimp trips were defined as those trips for which rock shrimp were the most abundant in the landings (always outside vessel trips).

Stratum expansion factors are summarized for Georgia/Inside for catch (Table 5) and trips (Table 7). Stratum expansion factors are summarized for Georgia/Outside for catch (Table 6) and for trips (Table 9).

South Carolina: NMFS detailed shrimp data were available from 1979-1995, of which late season 1995 information are preliminary (Table 2). Boat trips have not been separated from vessel trips since 1991, but represent a very small level of effort.

Seasonal definitions for stratification were the same as for Florida. Again, rock shrimp trips were defined as those trips for which rock shrimp were the most abundant in the landings (always outside vessel trips).

Stratum expansion factors are summarized for South Carolina (Outside) for catch (Table 6) and for trips (Table 9). The negligible inside trips were pooled with the outside trips.

North Carolina: NMFS detailed shrimp data were available from 1978-1992 (trip information from 1992 are highly suspect). Only catch information was available for 1993 from the General Canvas data set (Linda Hardy, NMFS Beaufort). NC trip ticket data were made available for 1994-1995 by Walter Gibson (NC DMF, Morehead City, NC). These data are all summarized in Table 4. Mean catch per trip for 1988-1991 was used to estimate trips from catch for 1992 and 1993. The number of trips from 1994 and 1995 are much greater than for recent years, but not out of line with values

from the late 1970s and early 1980s. The trip ticket information could not be used to separate trips into type (boat/vessel) and shrimp species (i.e,, to allow for post-stratification of Fall trips into Fall Pink or Fall White trips).

Seasonal strata were modified as follows: Winter includes Jan.-Mar., spring includes Apr.-May, summer includes Jun.-Sep., and fall includes Oct.-Dec. No rock shrimp strata was defined for North Carolina.

Stratum expansion factors are summarized for North Carolina (Inside and Outside) for catch (Table 7) and for trips (Table 10).

## CHARACTERIZATION/BRD SAMPLES AND STRATA ESTIMATES OF FINFISH BYCATCH

Data available from characterization and BRD studies are summarized by strata in Table 11. Expansion estimates of finfish bycatch numbers will not be made for strata containing one or fewer sampled characterization/BRD trips (e.g., FL(N)-SC/Outside area during winter 1993-1994, and NC (Inside) during spring 1994-1995). Because of data incompleteness, the 1995-1996 fishing year for king and Spanish mackerel was also not included in this analysis. Note that no cobia were caught as bycatch in any trip so far sampled. Hence, best estimate of bycatch for cobia is 0.

Based on the mackerel fishing year (April 1 - March 31), catches from strata for which there were at least two trips sampled compared to total penaeid shrimp trawl catches (total catch of all shrimp from penaeid trips) were 74% (16.8 million pounds from sampled strata divided by 22.6 million pounds for all strata) in 1992-1993, 84% (20.6 million pounds divided by 24.6 million pounds) in 1993-1994, and 68% (16.4 million pounds divided by 24.1 million pounds) in 1994-1995.

Similarly, trips from strata for which there were at least two trips sampled compared to total penaeid shrimp trawl trips (total were 62% (31057 divided by 50488) in 1992-1993, 66% (33368 divided by 50381) in 1993-1994, and 55% (38850 divided by 70173) in 1994-1995.

Length frequency distributions for Spanish mackerel in 10 mm total length intervals are summarized by fishing year (April 1 - March 31) for 1992-1995 data (Fig. 1). A wider spread of size classes are noted in 1993 and 1995 fishing years compared to 1992 and 1994 fishing years.

Expansion by Catch: This approach sums finfish and shrimp landings across all tows from a trip. The mean finfish:shrimp ratio in weight is then calculated from all trips for a each stratum. This ratio times the shrimp catch for that stratum produces and estimate of bycatch in weight. Dividing bycatch in weight by mean weight of bycatch in that stratum gives an estimate of bycatch in numbers for that strata. Expansion for king and Spanish mackerel bycatch numbers based on catch are summarized in Tables 12-13

Expansion by Trips: This approach calculates the number of finfish caught per trip (CPE) and multiplies by trips within a strata to obtain an estimate of bycatch in numbers for that strata. As described in SEAMAP-SA Bycatch Working Group (1995) report, finfish caught per trip must by expanded up from individually sampled tows to all tows and for multiple nets pulled during a tow. Expansion for king and Spanish mackerel bycatch numbers based on trips are summarized in Tables 14-15.

## DISCUSSION

An advantage of expanding by catch, rather than trip, are primarily associated with a less rigorous need for externally

consistant trip definitions between strata or even within strata. Also, the estimation of numbers of nets per vessel is much less critical and does not introduce additional error in the estimation process. A concern would be a proper expression of variance associated with the expanded strata estimate because of the greater complexity in the expansion (F:S times mean weight of finfish times shrimp catch). Another minor concern with catch expansion is concerned with lack of data for rock shrimp fishery and increased importance in expansion (few trips, large catches). And even with catch expansion subsetting of trips by tows is still of some concern. Further, there seem to be several characterization/BRD trips for which bycatch was counted but not weighed. Thus some trips drop out of the F:S ratio approach.

In considering these strata estimates for expansion to annual estimates for the U.S. south Atlantic coast several factors must by considered. First, are within-strata sample sizes adequate? We have deleted sample sizes of one from consideration, but are sample sizes of 2 or 3 sufficient? Estimates of strata-specific coefficients of variation (CV) and percent standard error (PSE= CV/$\sqrt{n}$) are included at the strata-level to evaluate this concern, but note these are generally quite large. Only the PSEs for Spanish mackerel based on trip expansions might by of an acceptable level (for Spanish mackerel values of PSE range between 20 and 78% in Table 15 versus values range between 5 and 1904% with 9 out of 15 greater than 100% in Table 13).

A second concern is expansion of strata estimates for which samples are available to strata for which no data is available. This would imply one of two assumptions. Either the finfish:shrimp ratio for sampled strata can be applied to unsampled strata or catch-per-effort for sampled strata can be applied to unsampled strata. Also, does a sufficiently large percentage of catch or trips associated with sampled strata outway concerns about deviations from the above assumptions when expanding bycatch estimates to unsampled strata?

No characterization/BRD data were available for use in this analysis for inside waters for Florida through South Carolina and outside waters from North Carolina. Inside trips have been quite significant in Florida and Georgia, especially since 1988 (Tables 1 and 2), and outside trips are by no means trivial in North Carolina (Table 4).

Finally, only one rock shrimp sampled trip (off Florida in winter 1995) was available to characterize rock shrimp trips. Rock shrimp trips varied by fishing years with 330 in 1992, 380 in 1993 and 548 in 1994. Total shrimp catches from rock shrimp trips were 3.2 million pounds in 1992, 5.7 million pounds in 1993, and 7.0 million pounds in 1994.

## LITERATURE CITED

SEAMAP-South Atlantic Bycatch Working Group. 1995. Estimates of Finfish Bycatch in the South Atlantic Shrimp Fishery. ASMFC, Washington, DC. (draft)

**Table 1.** Annual catch (1000 pounds), effort (trips), and catch per effort (CPE, pounds per trip) for boats, vessels, and combined from Florida Trip Ticket database (source: Martha Norris, Florida Department of Environmental Protection).

| Year | Inside | | | Outside | | | Combined | | |
|---|---|---|---|---|---|---|---|---|---|
| | Catch | Trips | CPE | Catch | Trips | CPE | Catch | Trips | CPE |
| 1986 | 895.8 | 6741 | 132.9 | 4560.8 | 3496 | 1304.5 | 5456.6 | 10237 | 533.0 |
| 1987 | 694.5 | 7356 | 94.4 | 5656.7 | 3509 | 1612.0 | 6351.1 | 10865 | 584.6 |
| 1988 | 1271.1 | 8179 | 155.4 | 4465.1 | 2961 | 1507.7 | 5736.2 | 11141 | 514.9 |
| 1989 | 1623.8 | 8139 | 199.5 | 6756.8 | 2852 | 2369.2 | 8380.6 | 10991 | 762.5 |
| 1990 | 1297.1 | 8302 | 156.2 | 6061.7 | 2634 | 2301.2 | 7358.7 | 10936 | 672.9 |
| 1991 | 1272.7 | 8122 | 156.7 | 4001.1 | 3029 | 1320.9 | 5273.7 | 11151 | 472.9 |
| 1992 | 1499.8 | 7810 | 192.0 | 5203.4 | 2668 | 1950.5 | 6703.2 | 10478 | 639.7 |
| 1993 | 1264.5 | 7203 | 175.6 | 7299.2 | 2512 | 2905.5 | 8563.7 | 9715 | 881.5 |
| 1994 | 1342.9 | 8446 | 159.0 | 9339.0 | 4112 | 2271.0 | 10681.9 | 12558 | 850.6 |
| 1995[a] | 802.6 | 6082 | 132.0 | 8208.5 | 3856 | 2128.7 | 9011.2 | 9938 | 906.7 |

[a] Preliminary.

Note: Catch and trips for unknown distance (inside and outside) were partitioned separately based on known catch and trips (distance and/or latitude).

**Table 2.** Annual catch (1000 pounds), effort (trips), and catch per effort (CPE, pounds per trip) for inside, outside, and combined for Georgia from NMFS Detailed Shrimp database, 1978-1995.

| Year | Inside | | | Outside | | | Combined | | |
|---|---|---|---|---|---|---|---|---|---|
| | Catch | Trips | CPE | Catch | Trips | CPE | Catch | Trips | CPE |
| 1978 | 72.9 | 931 | 77.4 | 5248.7 | 9781 | 536.6 | 5320.8 | 10712 | 496.7 |
| 1979 | 172.7 | 1049 | 164.7 | 9540.1 | 13598 | 701.6 | 9712.8 | 14647 | 663.1 |
| 1980 | 72.9 | 735 | 99.2 | 8329.3 | 12427 | 670.3 | 8402.3 | 13162 | 638.4 |
| 1981 | 25.2 | 288 | 87.7 | 4899.9 | 6436 | 761.3 | 4925.2 | 6724 | 732.5 |
| 1982 | 50.5 | 371 | 136.0 | 6684.0 | 10878 | 614.5 | 6734.4 | 11249 | 598.7 |
| 1983 | 39.4 | 282 | 139.6 | 7649.4 | 12031 | 635.8 | 7688.8 | 12313 | 624.5 |
| 1984 | 7.9 | 116 | 68.3 | 3469.7 | 5567 | 623.3 | 3477.6 | 5683 | 611.9 |
| 1985 | 79.1 | 449 | 176.2 | 7088.4 | 7075 | 1001.9 | 7167.5 | 7524 | 952.6 |
| 1986 | 70.1 | 494 | 142.0 | 7419.0 | 9531 | 778.4 | 7489.1 | 10025 | 747.0 |
| 1987 | 15.9 | 162 | 98.0 | 7255.9 | 9083 | 798.9 | 7271.8 | 9245 | 786.6 |
| 1988 | 115.0 | 4166 | 27.6 | 6915.5 | 8519 | 811.7 | 7030.2 | 12685 | 554.2 |
| 1989 | 135.5 | 4400 | 30.8 | 7645.2 | 7639 | 1000.8 | 7780.7 | 12039 | 646.3 |
| 1990 | 98.3 | 3462 | 28.4 | 5982.9 | 6236 | 959.4 | 6081.2 | 9698 | 627.1 |
| 1991 | 117.9 | 4256 | 27.7 | 9053.5 | 10129 | 893.8 | 9171.3 | 14385 | 637.6 |
| 1992 | 109.8 | 3721 | 29.5 | 7855.9 | 8919 | 880.8 | 7965.7 | 12640 | 630.2 |
| 1993 | 112.0 | 3802 | 29.5 | 7694.4 | 8963 | 858.5 | 7806.4 | 12765 | 611.5 |
| 1994 | 120.1 | 3645 | 32.9 | 7094.5 | 8473 | 837.3 | 7214.6 | 12118 | 595.4 |
| 1995[a] | 100.6 | 2310 | 43.5 | 7953.4 | 6510 | 1221.7 | 8054.0 | 8820 | 913.1 |

[a] Preliminary.

**Table 3.** Annual catch (1000 pounds), effort (trips), and catch per effort (CPE, pounds per trip) for inside, outside, and combined for South Carolina from NMFS Detailed Shrimp database, 1979-1995.

| Year | Inside | | | Outside | | | Combined | | |
|---|---|---|---|---|---|---|---|---|---|
| | Catch | Trips | CPE | Catch | Trips | CPE | Catch | Trips | CPE |
| 1979 | 626.9 | 1255 | 499.5 | 6034.8 | 10035 | 601.4 | 6661.7 | 11290 | 590.1 |
| 1980 | 1042.8 | 2780 | 375.1 | 5926.7 | 11892 | 498.4 | 6969.5 | 14672 | 475.0 |
| 1981 | 571.3 | 1599 | 357.3 | 2352.6 | 7281 | 323.1 | 2923.8 | 8880 | 329.3 |
| 1982 | 807.5 | 1900 | 424.9 | 4203.3 | 12021 | 349.7 | 5010.7 | 13921 | 359.9 |
| 1983 | 735.7 | 1658 | 443.8 | 4572.0 | 8962 | 510.2 | 5307.7 | 10620 | 499.8 |
| 1984 | 113.3 | 493 | 229.9 | 3001.6 | 5134 | 584.7 | 3115.0 | 5627 | 553.6 |
| 1985 | 240.2 | 728 | 329.9 | 3162.8 | 4724 | 669.5 | 3403.0 | 5452 | 624.1 |
| 1986 | 26.4 | 140 | 188.7 | 5776.9 | 9742 | 593.0 | 5803.3 | 9882 | 587.3 |
| 1987 | 29.4 | 55 | 533.8 | 5190.7 | 11383 | 456.0 | 5220.1 | 11438 | 436.4 |
| 1988 | 32.6 | 36 | 906.3 | 4275.4 | 8351 | 511.9 | 4308.1 | 8387 | 513.6 |
| 1989 | 35.5 | 56 | 633.6 | 7177.5 | 10169 | 705.8 | 7213.0 | 10225 | 705.4 |
| 1990 | 2.6 | 21 | 125.8 | 5503.9 | 9634 | 571.3 | 5506.6 | 9655 | 570.3 |
| 1991 | 11.0 | 18 | 613.0 | 8985.3 | 14375 | 625.1 | 8996.3 | 14393 | 625.0 |
| 1992 | 0.7 | 1 | 716.1 | 6486.1 | 12984 | 499.5 | 6486.8 | 12985 | 499.5 |
| 1993 | 6.3 | 15 | 422.7 | 7914.9 | 12219 | 647.8 | 7921.3 | 12234 | 647.5 |
| 1994 | 20.0 | 113 | 177.3 | 5181.2 | 10838 | 478.1 | 5201.2 | 10951 | 475.0 |
| 1995[a] | 87.8 | 229 | 383.5 | 10347.5 | 12923 | 800.7 | 10435.3 | 13152 | 793.4 |

[a] Preliminary.

**Table 4.** Annual catch (1000 pounds), effort (trips), and catch per effort (CPE, pounds per trip) for inside, outside, and combined for North Carolina from NMFS Detailed Shrimp database, 1978-1992.

| Year | Inside | | | Outside | | | Combined | | |
|---|---|---|---|---|---|---|---|---|---|
| | Catch | Trips | CPE | Catch | Trips | CPE | Catch | Trips | CPE |
| 1978 | 1809.7 | 11462 | 157.9 | 1070.5 | 2101 | 509.5 | 2880.2 | 13563 | 212.3 |
| 1979 | 3131.8 | 13721 | 228.3 | 1481.6 | 2851 | 519.7 | 4613.4 | 16572 | 278.4 |
| 1980 | 7628.5 | 29477 | 258.8 | 1582.4 | 3260 | 485.4 | 9210.9 | 32737 | 281.4 |
| 1981 | 1940.5 | 22645 | 85.7 | 491.6 | 1824 | 269.5 | 2432.1 | 24469 | 99.4 |
| 1982 | 5065.1 | 34378 | 147.3 | 1601.1 | 3612 | 443.2 | 6666.2 | 37991 | 175.5 |
| 1983 | 4282.6 | 32516 | 131.7 | 1602.0 | 4043 | 396.2 | 5884.7 | 36560 | 161.0 |
| 1984 | 3027.3 | 22856 | 132.5 | 1655.2 | 4473 | 370.0 | 4682.5 | 27329 | 171.3 |
| 1985 | 10013.1 | 21896 | 457.3 | 1384.2 | 2310 | 599.1 | 11397.3 | 24206 | 470.8 |
| 1986 | 4768.5 | 21743 | 219.3 | 1199.9 | 2444 | 491.0 | 5968.4 | 24187 | 246.8 |
| 1987 | 3036.9 | 16588 | 183.1 | 1170.3 | 2721 | 430.1 | 4207.2 | 19310 | 217.9 |
| 1988 | 6015.1 | 20928 | 287.4 | 1854.7 | 3996 | 464.1 | 7869.9 | 24924 | 315.8 |
| 1989 | 6569.8 | 25834 | 254.3 | 2073.4 | 4273 | 485.2 | 8643.1 | 30107 | 287.1 |
| 1990 | 6145.9 | 17097 | 359.5 | 1392.9 | 2482 | 561.2 | 7538.7 | 19579 | 385.0 |
| 1991 | 8812.5 | 21945 | 401.6 | 1351.3 | 2848 | 474.5 | 10163.8 | 24793 | 410.0 |
| 1992[a] | 4233.0 | 13871 | 305.2 | 967.8 | 1854 | 522.0 | 5200.8 | 15105 | 344.3 |
| 1993[b] | 4345.0 | 12876 | 337.4 | 1799.2 | 3493 | 515.1 | 6144.2 | 16369 | 375.4 |
| 1994[c] | 5628.0 | 28642 | 196.5 | 1638.4 | 5184 | 316.0 | 7266.4 | 33826 | 214.8 |
| 1995[c] | 6501.1 | 32485 | 200.1 | 2138.2 | 5946 | 359.6 | 8639.3 | 38431 | 224.8 |

[a] Based on catch from 1992 NMFS Detailed Shrimp database and trips estimated from mean catch- per-trip for 1988-1991.

[b] Based on catch from General Canvas and trips from mean catch-per-trip for 1988-1991 adjusted for season and inside/outside landings.

[c] From North Carolina trip ticket database (provided by Walter Gibson, NC DMF).

**Table 5.** Florida trips (catch expansion factors) estimated from Florida Trip Ticket database for all inside and for outside south of 30° N latitude and Georgia catches (catch expansion factors) censused from NMFS Detailed Shrimp database for inside for 1992-1995.

| Year | Penaeid Shrimp[a] | | | | Rock Shrimp | Total |
|---|---|---|---|---|---|---|
| | Winter | Spring | Summer | Fall | | |
| | | | Florida: Inside | | | |
| 1992 | 330.2 | 188.5 | 212.7 | 768.4 | 0.0 | 1499.8 |
| 1993 | 278.0 | 177.6 | 234.4 | 574.6 | 0.0 | 1264.5 |
| 1994 | 322.8 | 259.2 | 334.8 | 426.1 | 0.0 | 1342.9 |
| 1995[b] | 157.1 | 159.5 | 186.1 | 300.1 | 0.0 | 802.6 |
| | | | Florida (South)[b]: Outside | | | |
| 1992 | 465.5 | 186.3 | 131.9 | 1587.1 | 2619.2 | 4990.0 |
| 1993 | 536.2 | 235.8 | 303.5 | 787.1 | 5338.7 | 7201.3 |
| 1994 | 267.2 | 116.7 | 158.8 | 648.7 | 6563.7 | 7755.1 |
| 1995[b] | 406.0 | 146.4 | 122.5 | 446.7 | 4754.2 | 5875.8 |
| | | | Georgia: Inside | | | |
| 1992 | 14.4 | 21.5 | 20.3 | 53.6 | 0.0 | 109.8 |
| 1993 | 10.7 | 30.2 | 23.6 | 47.5 | 0.0 | 112.0 |
| 1994 | 10.3 | 21.3 | 31.7 | 56.8 | 0.0 | 120.1 |
| 1995[b] | 15.7 | 30.0 | 29.5 | 25.5 | 0.0 | 100.6 |

[a] Seasonal definitions in text.
[b] Preliminary.

**Table 6.** Florida (north of 30° N latitude) through South Carolina catches (catch expansion factors) estimated from Florida Trip Ticket and censused NMFS Detailed Shrimp databases for outside by season for 1992-1995.

| Year | Penaeid Shrimp[a] | | | | Rock Shrimp | Total |
|---|---|---|---|---|---|---|
| | Winter | Spring | Summer | Fall | | |
| **1992:** | | | | | | |
| SC | 441.4 | 1129.9 | 1401.6 | 3513.9 | 0.0 | 6486.8 |
| GA | 647.5 | 2309.9 | 941.6 | 3390.8 | 566.1 | 7855.9 |
| FL (North) | 120.2 | 40.2 | 22.8 | 30.2 | 0.0 | 213.4 |
| Total | 1209.1 | 3480.0 | 2366.0 | 6934.9 | 566.1 | 14556.1 |
| **1993:** | | | | | | |
| SC | 231.0 | 2156.7 | 2564.6 | 2969.0 | 0.0 | 7921.3 |
| GA | 403.6 | 2215.9 | 1730.3 | 2951.2 | 393.4 | 7694.4 |
| FL (North) | 3.9 | 59.2 | 23.1 | 11.7 | 0.0 | 97.9 |
| Total | 638.5 | 4431.8 | 4318.0 | 5931.9 | 393.4 | 15713.6 |
| **1994:** | | | | | | |
| SC | 203.8 | 790.4 | 1386.8 | 2819.8 | 0.4 | 5201.2 |
| GA | 497.8 | 1088.9 | 1223.4 | 3841.7 | 442.7 | 7094.5 |
| FL (North) | 4.8 | 179.2 | 371.5 | 1028.4 | 0.0 | 1583.9 |
| Total | 706.4 | 2058.5 | 2981.7 | 7689.9 | 443.1 | 13879.6 |
| **1995[b]:** | | | | | | |
| SC | 428.7 | 2551.4 | 1747.6 | 5707.6 | 0.0 | 10435.3 |
| GA | 873.8 | 3389.9 | 1377.4 | 2031.5 | 280.8 | 7953.4 |
| FL (North) | 52.1 | 592.6 | 745.0 | 943.2 | 0.0 | 2332.9 |
| Total | 1354.6 | 6533.9 | 3870.0 | 8682.3 | 280.8 | 20721.6 |

[a] Seasonal definitions in text.
[b] Preliminary.

**Table 7.** North Carolina catches (catch expansion factors) by strata censused from General Canvas for 1992-1993 and from trip ticket database for 1994-1995.

| Year | Strata | Seasons[a] Winter | Spring | Summer | Fall | Total |
|---|---|---|---|---|---|---|
| 1992 | Inside | 20.1 | 340.6 | 3382.8 | 489.6 | 4233.0 |
| | Outside | 3.1 | 55.7 | 716.6 | 192.3 | 967.8 |
| | Total | 23.2 | 396.3 | 4099.4 | 681.9 | 5200.8 |
| 1993 | Inside | 7.0 | 125.9 | 2868.4 | 1343.6 | 4345.0 |
| | Outside | 16.8 | 30.8 | 1414.4 | 337.3 | 1799.2 |
| | Total | 23.8 | 156.7 | 4282.8 | 1680.9 | 6144.2 |
| 1994 | Inside | 13.1 | 249.2 | 3990.8 | 1374.8 | 5628.0 |
| | Outside | 20.4 | 124.5 | 932.6 | 560.8 | 1638.4 |
| | Total | 33.5 | 373.7 | 4923.4 | 1935.6 | 7266.4 |
| 1995[b] | Inside | 47.5 | 371.9 | 4105.7 | 1976.0 | 6501.1 |
| | Outside | 59.2 | 111.9 | 1174.9 | 792.1 | 2138.2 |
| | Total | 106.7 | 483.8 | 5280.6 | 2768.1 | 8639.3 |

[a] Seasonal definitions in text.
[b] Preliminary.

**Table 8.** Florida trips (trip expansion factors) estimated from Florida Trip Ticket database for all inside and for outside south of 30° N latitude and Georgia trips (trip expansion factors) censused from NMFS Detailed Shrimp database for inside for 1992-1995.

| Year | Penaeid Shrimp[a] | | | | Rock Shrimp | Total |
|---|---|---|---|---|---|---|
| | Winter | Spring | Summer | Fall | | |
| | | | Florida: Inside | | | |
| 1992 | 2025 | 1471 | 1604 | 2710 | 0 | 7810 |
| 1993 | 1630 | 1465 | 1363 | 2744 | 0 | 7202 |
| 1994 | 1972 | 2141 | 1561 | 2772 | 0 | 8446 |
| 1995[b] | 1750 | 1502 | 1001 | 1829 | 0 | 6082 |
| | | | Florida (South)[b]: Outside | | | |
| 1992 | 751 | 197 | 262 | 964 | 273 | 2447 |
| 1993 | 678 | 214 | 332 | 562 | 348 | 2134 |
| 1994 | 513 | 187 | 219 | 518 | 496 | 1933 |
| 1995[b] | 587 | 191 | 167 | 302 | 345 | 1592 |
| | | | Georgia: Inside | | | |
| 1992 | 488 | 886 | 726 | 1621 | 0 | 3721 |
| 1993 | 398 | 919 | 782 | 1703 | 0 | 3802 |
| 1994 | 390 | 797 | 958 | 1500 | 0 | 3645 |
| 1995[b] | 464 | 857 | 659 | 330 | 0 | 2310 |

[a] Seasonal definitions in text.
[b] Preliminary.

**Table 9.** Florida (north of 30° N latitude) through South Carolina trips (trip expansion factors) estimated from Florida Trip Ticket and censused NMFS Detailed Shrimp databases for outside by season for 1992-1995.

| Year | Penaeid Shrimp[a] | | | | Rock Shrimp | Total |
|---|---|---|---|---|---|---|
| | Winter | Spring | Summer | Fall | | |
| **1992:** | | | | | | |
| SC | 797 | 2262 | 2869 | 7058 | 0 | 12986 |
| GA | 1027 | 2197 | 1540 | 4098 | 57 | 8919 |
| FL (North) | 65 | 46 | 30 | 81 | 0 | 222 |
| Total | 1889 | 4505 | 4439 | 11237 | 57 | 22127 |
| **1993:** | | | | | | |
| SC | 736 | 2538 | 3016 | 5943 | 0 | 12233 |
| GA | 758 | 2287 | 1976 | 3910 | 32 | 8963 |
| FL (North) | 27 | 214 | 73 | 64 | 0 | 378 |
| Total | 1521 | 5039 | 5065 | 9917 | 32 | 21574 |
| **1994:** | | | | | | |
| SC | 343 | 1453 | 3011 | 6135 | 8 | 10950 |
| GA | 592 | 1737 | 1865 | 4235 | 44 | 8473 |
| FL (North) | 30 | 500 | 510 | 1140 | 0 | 2180 |
| Total | 965 | 3690 | 5386 | 11510 | 52 | 21603 |
| **1995[b]:** | | | | | | |
| SC | 929 | 3072 | 2729 | 6422 | 0 | 13152 |
| GA | 897 | 2525 | 1735 | 1325 | 28 | 6510 |
| FL (North) | 167 | 697 | 706 | 693 | 0 | 2263 |
| Total | 1993 | 6294 | 5170 | 8440 | 28 | 21925 |

[a] Seasonal definitions in text.
[b] Preliminary.

**Table 10.** North Carolina trips (trip expansion factors) by strata estimated for 1992-1993 and censused from trip ticket database for 1994-1995.

| Year | Strata | Seasons[a] | | | | Total |
|---|---|---|---|---|---|---|
| | | Winter | Spring | Summer | Fall | |
| 1992 | Inside | 252 | 2713 | 9355 | 1551 | 13871 |
| | Outside | 5 | 175 | 1337 | 337 | 1854 |
| | Total | 257 | 2888 | 10692 | 1888 | 15725 |
| 1993 | Inside | 91 | 813 | 8019 | 3953 | 12876 |
| | Outside | 80 | 96 | 2707 | 610 | 3493 |
| | Total | 171 | 909 | 10726 | 4563 | 16369 |
| 1994 | Inside | 180 | 2662 | 19374 | 6426 | 28642 |
| | Outside | 58 | 569 | 3013 | 1544 | 5184 |
| | Total | 238 | 3231 | 22387 | 7970 | 33826 |
| 1995[b] | Inside | 418 | 3554 | 21479 | 7034 | 32485 |
| | Outside | 134 | 553 | 3097 | 2162 | 5946 |
| | Total | 552 | 4107 | 24576 | 9196 | 38431 |

[a] Seasonal definitions in text.
[b] Preliminary.

**Table 11.** Summary of characterization and BRD study samples used to estimate bycatch in the U.S. south Atlantic shrimp trawl fishery with strata expansion factors based on shrimp trawl catch (1000 lbs) and trips by fishing year (April-March).

| Area[a] | Season | Trips | Tows | Hours | Stratum Expansion Catch | Stratum Expansion Trips |
|---|---|---|---|---|---|---|
| | | | 1992-93 | | | |
| FGS | Spring | 9 | 15 | 46.6 | 3480.0 | 4505 |
| FGS | Summer | 6 | 14 | 45.2 | 2366.0 | 4439 |
| FGS | Fall | 26 | 45 | 137.8 | 6934.9 | 11237 |
| FGS | Winter | 5 | 8 | 21.8 | 638.5 | 1521 |
| NCI | Summer | 21 | 30 | 39.4 | 3382.8 | 9355 |
| | Total: | 67 | 112 | 290.8 | 16802.2 | 31057 |
| | | | 1993-94 | | | |
| FSO | Fall | 4 | 32 | 78.4 | 1587.1 | 562 |
| FGS | Spring | 3 | 38 | 134.5 | 4431.8 | 5039 |
| FGS | Summer | 8 | 110 | 325.5 | 4318.0 | 5065 |
| FGS | Fall | 14 | 88 | 284.1 | 5931.9 | 9917 |
| **FGS** | **Winter** | **1** | **2** | **9.0** | **706.4** | **965** |
| NCI | Spring | 12 | 42 | 71.8 | 125.9 | 813 |
| NCI | Summer | 88 | 166 | 231.1 | 2868.4 | 8019 |
| NCI | Fall | 3 | 6 | 4.2 | 1343.6 | 3953 |
| | Total: | 133 | 484 | 1138.6 | 21313.1 | 34333 |
| | | | 1994-95 | | | |
| FSO | Winter | 4 | 46 | 228.8 | 406.0 | 587 |
| FGS | Summer | 10 | 46 | 158.8 | 2981.7 | 5386 |
| FGS | Fall | 13 | 67 | 248.6 | 7689.9 | 11510 |
| FGS | Winter | 2 | 25 | 81.5 | 1354.6 | 1993 |
| **NCI** | **Spring** | **1** | **1** | **0.5** | **249.2** | **2662** |
| NCI | Summer | 20 | 117 | 97.5 | 3990.8 | 19374 |
| | Total: | 50 | 302 | 815.7 | 16672.2 | 41512 |
| | | | 1995-96 | | | |
| **FSO** | **Spring** | **1** | **9** | **40.2** | **146.4** | **191** |
| FGS | Spring | 9 | 43 | 142.2 | 6533.9 | 6294 |
| FGS | Summer | 12 | 44 | 132.0 | 3870.0 | 5170 |
| FGS | Fall | 4 | 4 | 6.5 | 8682.3 | 8440 |
| | Total: | 26 | 100 | 320.9 | 19232.6 | 20095 |

[a] FSO - Florida (South of 30° N latitude, Outside); FGS - Florida (North) to South Carolina (Outside); NCI - North Carolina (Inside).

**Table 12.** Expanded estimates (1000) of bycatch of king mackerel in the U.S. south Atlantic shrimp trawl fishery based on within-strata expansion by finfish to shrimp ratio by weight and shrimp catch (1000 lbs).

| Area[a] | Season | Shrimp Catch | Fin:Shr Ratio | Mean Weight | Finfish Catch | CV | PSE |
|---|---|---|---|---|---|---|---|
| | | | 1992-93 | | | | |
| FGS | Spring | 3480.0 | 0.0 | - | 0.0 | - | - |
| FGS | Summer | 2366.0 | 0.00348 | 0.019 | 434.1 | 366.5 | 149.6 |
| FGS | Fall | 6934.9 | 0.00007 | 0.036 | 13.5 | 24294.8 | 4764.6 |
| FGS | Winter | 638.5 | 0.0 | - | 0.0 | - | - |
| NCI | Summer | 3382.8 | 0.0 | - | 0.0 | - | - |
| | Total: | 16802.2 | | | 447.6 | | |
| | | | 1993-94 | | | | |
| FSO | Fall | 787.1 | 0.0 | - | 0.0 | - | - |
| FGS | Spring | 4431.8 | 0.0 | - | 0.0 | - | - |
| FGS | Summer | 4318.0 | 0.0 | - | 0.0 | - | - |
| FGS | Fall | 5931.9 | 0.00144 | 0.106 | 80.3 | 5197.1 | 1389.0 |
| NCI | Spring | 125.9 | 0.0 | - | 0.0 | - | - |
| NCI | Summer | 2868.4 | 0.0 | - | 0.0 | - | - |
| NCI | Fall | 1343.6 | 0.0 | - | 0.0 | - | - |
| | Total: | 19806.7 | | | 80.3 | | |
| | | | 1994-95 | | | | |
| FSO | Winter | 406.0 | 0.0 | - | 0.0 | - | - |
| FGS | Summer | 2981.7 | 0.00343 | 0.077 | 132.5 | - | - |
| FGS | Fall | 7689.9 | 0.00012 | 0.038 | 23.9 | 11568.6 | 3208.6 |
| FGS | Winter | 1341.6 | 0.0 | - | 0.0 | - | - |
| NCI | Summer | 3990.8 | 0.0 | - | 0.0 | - | - |
| | Total: | 16410.0 | | | 156.4 | | |

Note: $C_f = C_s * R/W$, where $C_f$ is finfish catch, $C_s$ is shrimp catch, R is finfish:shrimp ratio in weight, and W is mean weight of finfish.

**Table 13.** Expanded estimates (1000) of bycatch of Spanish mackerel in the U.S. south Atlantic shrimp trawl fishery based on within-strata expansion by finfish to shrimp ratio by weight and shrimp catch (1000 lbs).

| Area[a] | Season | Shrimp Catch | Fin:Shr Ratio | Mean Weight | Finfish Catch | CV | PSE |
|---|---|---|---|---|---|---|---|
| | | | 1992-93 | | | | |
| FGS | Spring | 3480.0 | 0.06199 | 0.486 | 443.7 | 234.6 | 78.2 |
| FGS | Summer | 2366.0 | 0.16440 | 0.169 | 2299.3 | 130.4 | 53.2 |
| FGS | Fall | 6934.9 | 0.01074 | 0.155 | 481.7 | 1578.3 | 309.5 |
| FGS | Winter | 638.5 | 0.0 | - | 0.0 | - | - |
| NCI | Summer | 3382.8 | 0.17911 | 0.055 | 10968.7 | 24.9 | 5.4 |
| | Total: | 16802.2 | | | 14193.4 | | |
| | | | 1993-94 | | | | |
| FSO | Fall | 787.1 | 0.00813 | 0.352 | 18.2 | 1142.2 | 571.1 |
| FGS | Spring | 4431.8 | 0.19131 | 0.576 | 1472.5 | 197.9 | 114.3 |
| FGS | Summer | 4318.0 | 0.04163 | 0.266 | 675.6 | 349.7 | 123.7 |
| FGS | Fall | 5931.9 | 0.01082 | 0.287 | 223.4 | 3638.1 | 972.3 |
| NCI | Spring | 125.9 | 0.01475 | 0.614 | 3.0 | 2390.2 | 436.4 |
| NCI | Summer | 2868.4 | 0.00300 | 0.023 | 382.3 | 552.6 | 75.9 |
| NCI | Fall | 1343.6 | 0.00708 | 0.422 | 22.5 | 8513.5 | 1903.7 |
| | Total: | 19806.7 | | | 2797.5 | | |
| | | | 1994-95 | | | | |
| FSO | Winter | 406.0 | 0.02540 | 0.396 | 26.1 | 208.8 | 104.4 |
| FGS | Summer | 2981.7 | 0.07230 | 0.146 | 1480.7 | 124.3 | 41.4 |
| FGS | Fall | 7689.9 | 0.01034 | 0.127 | 623.7 | 784.3 | 217.5 |
| FGS | Winter | 1341.6 | 0.0 | - | 0.0 | - | - |
| NCI | Summer | 3990.8 | 0.02989 | 0.034 | 3467.9 | 59.7 | 14.5 |
| | Total: | 16410.0 | | | 5598.4 | | |

Note: $C_f = C_s*R/W$, where $C_f$ is finfish catch, $C_s$ is shrimp catch, R is finfish:shrimp ratio in weight, and W is mean weight of finfish.

**Table 14.** Expanded estimates (1000) of bycatch of king mackerel in the U.S. south Atlantic shrimp trawl fishery based on within-strata expansion by effort as trips.

| | | | Finfish | | | |
|---|---|---|---|---|---|---|
| Area[a] | Season | Trips | CPE | Catch | CV | PSE |
| | | | 1992-93 | | | |
| FGS | Spring | 4505 | 0.0 | 0.0 | - | - |
| FGS | Summer | 4439 | 8.6 | 38.0 | 103.5 | 42.2 |
| FGS | Fall | 11237 | 0.4 | 4.5 | 374.2 | 73.4 |
| FGS | Winter | 1889 | 0.0 | 0.0 | - | - |
| NCI | Summer | 9355 | 0.0 | 0.0 | - | - |
| | Total: | 31425 | | 42.5 | | |
| | | | 1993-94 | | | |
| FSO | Fall | 562 | 0.0 | 0.0 | - | - |
| FGS | Spring | 5039 | 0.0 | 0.0 | - | - |
| FGS | Summer | 5065 | 0.0 | 0.0 | - | - |
| FGS | Fall | 9917 | 4.5 | 17.7 | 254.9 | 68.1 |
| NCI | Spring | 813 | 0.0 | 0.0 | - | - |
| NCI | Summer | 8019 | 0.0 | 0.0 | - | - |
| NCI | Fall | 3953 | 0.0 | 0.0 | - | - |
| | Total: | 33368 | | 17.7 | | |
| | | | 1994-95 | | | |
| FSO | Winter | 513 | 0.0 | 0.0 | - | - |
| FGS | Summer | 5386 | 12.0 | 64.4 | 316.3 | 100.0 |
| FGS | Fall | 11510 | 3.2 | 36.9 | 310.2 | 86.0 |
| FGS | Winter | 965 | 0.0 | 0.0 | - | - |
| NCI | Summer | 19374 | 0.0 | 0.0 | - | - |
| | Total: | 37748 | | 101.3 | | |

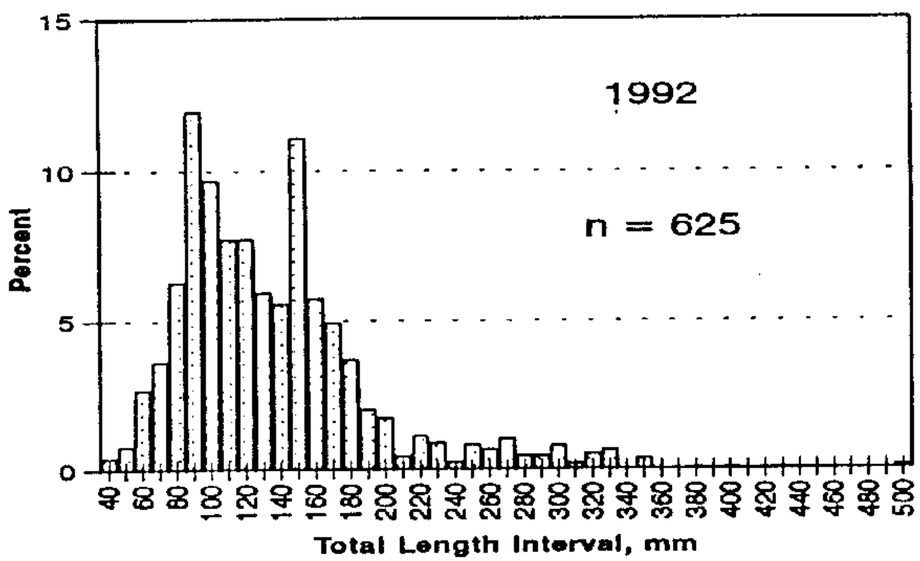
Note: $C_f$ = T*CPE, where $C_f$ = finfish catch, T is number of trips, and CPE if finfish catch per trips in the shrimp trawl fishery.

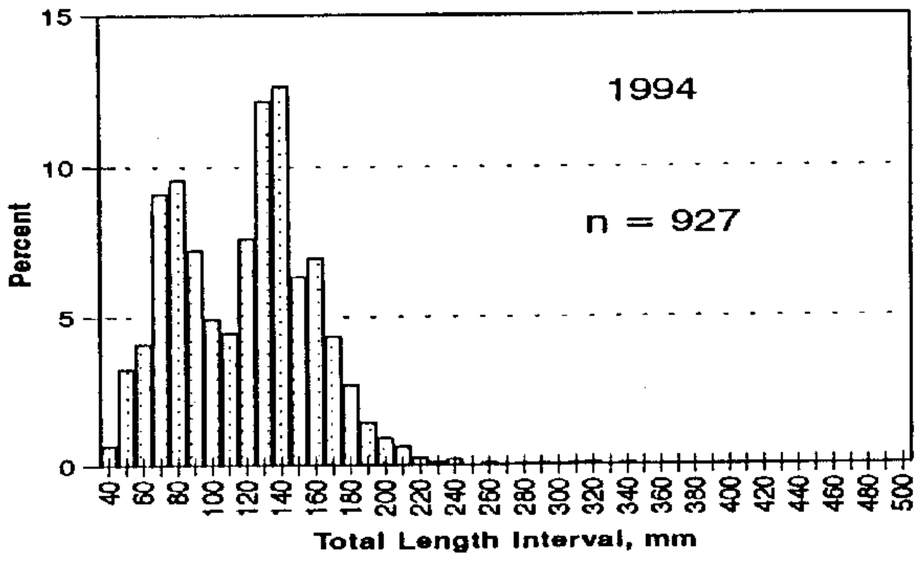
**Table 15.** Expanded estimates (1000) of bycatch of Spanish mackerel in the U.S. south Atlantic shrimp trawl fishery based on within-strata expansion by effort as trips.

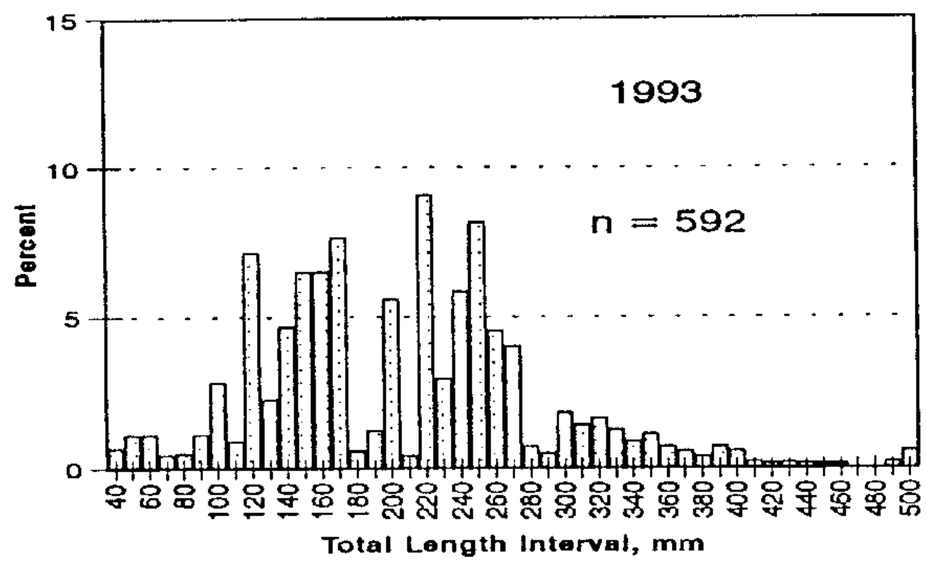
| Area[a] | Season | Trips | Finfish CPE | Finfish Catch | CV | PSE |
|---|---|---|---|---|---|---|
| | | | 1992-93 | | | |
| FGS | Spring | 4505 | 10.5 | 47.2 | 79.0 | 26.3 |
| FGS | Summer | 4439 | 36.0 | 160.0 | 59.3 | 24.2 |
| FGS | Fall | 11237 | 9.8 | 110.2 | 168.2 | 33.0 |
| FGS | Winter | 1889 | 0.0 | 0.0 | - | - |
| NCI | Summer | 9355 | 37.1 | 347.5 | 89.9 | 19.6 |
| | Total: | 31425 | | 664.9 | | |
| | | | 1993-94 | | | |
| FSO | Fall | 562 | 33.2 | 18.6 | 133.2 | 66.6 |
| FGS | Spring | 5039 | 344.8 | 1737.4 | 87.7 | 50.6 |
| FGS | Summer | 5065 | 129.9 | 657.8 | 220.4 | 77.9 |
| FGS | Fall | 9917 | 56.3 | 558.7 | 273.6 | 73.1 |
| NCI | Spring | 813 | 5.4 | 4.4 | 133.7 | 38.1 |
| NCI | Summer | 8019 | 4.5 | 36.0 | 421.7 | 45.0 |
| NCI | Fall | 3953 | 0.0 | 0.0 | - | - |
| | Total: | 33368 | | 3012.9 | | |
| | | | 1994-95 | | | |
| FSO | Winter | 513 | 33.5 | 17.2 | 48.1 | 24.0 |
| FGS | Summer | 5386 | 184.9 | 995.7 | 183.2 | 57.9 |
| FGS | Fall | 11510 | 18.3 | 210.6 | 156.2 | 43.3 |
| FGS | Winter | 965 | 0.0 | 0.0 | - | - |
| NCI | Summer | 19374 | 36.8 | 712.2 | 118.3 | 26.5 |
| | Total: | 37748 | | 1935.7 | | |

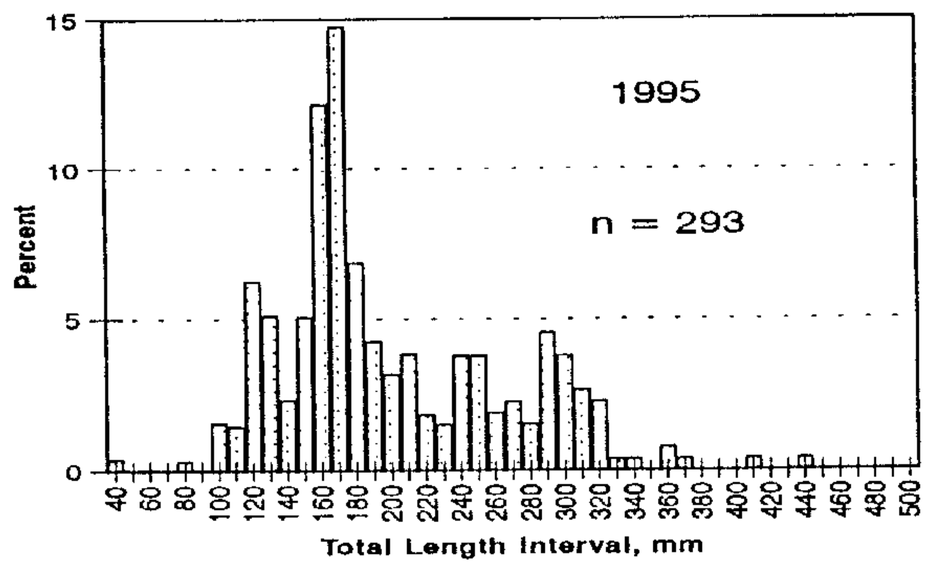
Note: $C_f$ = T*CPE, where $C_f$ = finfish catch, T is number of trips, and CPE if finfish catch per trips in the shrimp trawl fishery.

# Fig. 1. Weight length distributions (total length in millimeters) for Spanish Mackerel by fishing year.




Note: Weighting across stratum by number of total trips in stratum.